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Priority Paper 2

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GROUP 220
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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

In re: Application of David W. Joynson, et al.

Serial No. 457,406 Group: 220

Filed: November 30, 1982

For: RADAR TRACKING SYSTEM

New York, New York
February 23, 1983

Hon. Commissioner of Patents & Trademarks
Washington, D.C. 20231

Sir:

Applicants, through their attorneys, hereby claim the benefit of the filing of their British application No. 8136055 dated November 30, 1982 and in support thereof attach hereto a certified copy of said application.

This priority claim is made under Rule 55 of the Rules of Practice and Section 119 of the Patent Act of 1952.

Respectfully submitted,

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/rak

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PATENTS ACT 1977

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30 NOV 1981
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1 DEC 81 0293 PAT 0.007.00

8136055

REQUEST FOR GRANT OF A PATENT

THE GRANT OF A PATENT IS REQUESTED BY THE UNDERSIGNED ON THE BASIS OF THE PRESENT APPLICATION

1 Applicant's or Agent's Reference *(Please insert if available)* SDS/1965

11 Title of Invention RADAR TRACKING SYSTEM

111 Applicant or Applicants *(See note 2)*

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(a) ~~The applicant(s) is/are the sole/joint inventor(s)~~ ~~&~~

(b) A statement of Patents Form No. 7/77 is/~~will~~ be furnished

V Authorisation of Agent *(See note 4)* W.P. KEPPLER

V1 Address for Service *(See note 5)*

Central Patent Department, The General Electric Co. Ltd., Hirst Research Centre, Wembley, Middlesex, HA9 7PP

V11 Declaration of Priority *(See note 6)*

Country	Filing date	File number

V111 The Application claims an earlier date under Section 8(3), 12(6), 15(4), or 37(4) *(See note 7)*

Earlier application or patent number .... and filing date ....

1X Check List *(To be filled in by applicant or agent)*

A The application contains the following number of sheet(s)

1 Request .... 1 .... Sheet(s)
2 Description ... 22 .... Sheet(s)
3 Claim(s) .... Sheet(s)
4 Drawing(s) ..... 5 .... Sheet(s)
5 Abstract .... - .... Sheet(s)

B The application as filed is accompanied by:-

1 Priority document .... - ....
2 Translation of priority document ... - .....
3 Request for Search ....
4 Statement of Inventorship and Right to Grant .... - ....
5 Separate Authorisation of .... - .....

X It is suggested that Figure No ... 1 ... of the drawings (if any) should accompany the abstract when published

X1 Signature *(See note 8)*

For and on behalf of The Marconi Company Limited

J.D. Dolwin - Their Attorney

NOTES:

1 This form, when completed, should be brought or sent to the Patent Office together with the prescribed fee and two copies of the description of the invention.

2 The name , address and nationality of each applicant are to be stated in the spaces provided at 111. Names of natural persons should be indicated in full. Bodies corporate should be designated by their corporate name. If there are more than two applicants the information concerning the third (and further) applicants should be given on a separate sheet.

3 Where the applicant or applicants is/are the sole inventor or the joint inventors, the declaration (a) to that effect at 1V should be completed and the alternative statement (b) deleted. If however this is not the case the declaration (a) should be struck out and a statement will then be required to be filed upon Patents Form No.7/77.

4 If the applicant wished to appoint an agent, his name and address of his place of business shall be indicated in the spaces available at V and V1; such indication will be considered to be an authorisation for the agent to prosecute the application up to grant of a patent and to service any patent so granted.

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7 When an application is made by virtue of section 8(3), 12(6), 15(4), or 37(4) the appropriate section should be identified at V111 and the number of the earlier application or any patent granted thereon identified.

8 If the request is signed by an agent, an express authorisation signed by the applicant(s) must be received by the Patent Office before the expiry of 3 months from the filing date.

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RADAR TRACKING SYSTEM

SDS/~~1695~~ 1965

This invention relates to guidance systems for radar homing missiles and has an important application to anti-aircraft missiles employing a guidance system which is capable of acting in an active mode. An active mode is a mode in which the target is illuminated by radiation from the missile and in which reflected radiation from the target (termed "skin echo") is received by the missile during its flight, the missile having been launched on a course to intercept the target by a guidance system attached to a launching aircraft or platform. The reflected radiation is processed to obtain the bearings, azimuth and/or elevation, and the speed or range of the target so that the missile can follow the changes of direction and speed of the target.

An object of the present invention is the improvement of terminal accuracy in a pulse doppler radar seeker.

According to the present invention a missile guidance system comprises means for transmitting pulsed radiation to illuminate a target, a multi-element aerial arrangement arranged to respond to reflected radiation and provide a plurality of correspondingly pulsed output signals, receiver means for deriving from the aerial output signals sum and difference signals, together providing an indication of the presence and

position of a target, the receiver means including means for tracking a target in doppler frequency or in angle and adjusting the parameters according to the conditions.

The relevant features of one embodiment of a pulse doppler radar seeker will now be described, by way of example, with reference to the accompanying drawings, of which:-

Figure 1 is a basic block diagram;

Figure 2 is a block diagram of a doppler tracking loop applied to the arrangement of Figure 1;

Figure 3 is similarly a block diagram of an angle tracking loop applied to the arrangement of Figure 1.

Figure 4 is a table illustrating a combination of target confirmation tests,

and Figure 5 is a block diagram of an angle tracking and servo-control system.

In the guidance system shown in Figure 1 there are three front mixers 9, 10 and 61 to which the sum signal S, the azimuth difference signal D_a and the elevation difference signal D_e are applied. The three mixers 9, 10 and 61 feed range gates 23 in the three channels 19, 20 and 21. A further channel 62 to which the sum signal S is fed by way of mixer 9 has a split range gate 63 which is initially opened for only the first half of a range gate period and is inverted in

phase (i.e. given a gain of -1 to provide an output signal at an amplifier 64. The output signal from the amplifier 64 is applied to a Fast-Fourier-Transform filter bank (FFT) and thence into a range gate control circuit 33 which adjusts the opening times of all the range gates 23 to a time delay T as required to track the target in range.

At the output of the head amplifiers 13, 14 and 15 in the channels 20, 19 and 21, the difference signal D_e is added to a fraction k_e of the sum signal S (produced by a voltage controlled attenuator 66) to produce an output signal which is fed to the I.F. amplifier 25. The output signal from the I.F. amplifier 25 is fed to an electronic angle tracking phase-sensitive detector, to be described later, the output of which is zero when the difference channel 20 has zero signal. This occurs when $k_eS = D_e$. If the output of the difference channel 20 is not zero it passes the signal to an integrator which controls the value of k_e until the relationship $k_eS = D_e$ is satisfied. Since the target angle off aerial boresight is given by D_e/S then k_e equals this angle.

Similarly at the output of the head amplifier 14 the difference signal D_a is added to the sum signal S attenuated by an amount k_a in a voltage controlled

attenuator 67 to produce an output signal which is fed to the I.F. amplifier 25. The output signal from the I.F. amplifier 25 is fed to an electronic angle tracking phase-sensitive detector, the output of which is zero when the difference-channel 19 has zero signal in it. If the output of the difference channel 19 is not zero it passes the signal to an integrator which controls the value of k_a until the relationship $k_aS = D_a$ is satisfied. Since the target angle of aerial boresight is given by Da/S then k_a equals this.

The Fast-Fourier-Transform circuits provide outputs giving the complex amplitude in each of the FFT filter 'bins' (typically 16, 32, 64, 128 or 256 'bins' according to the bin width control setting.) The filter bin width is equal to the total FFT bandwidth divided by the number of filter bins and the output data rate is proportional to the bin width. Figure 2 shows how the sum FFT is used to control the doppler tracking loop and for target detection and confirmation.

Target detection is carried out on all the power outputs (i.e. the square of the sum of the real and imaginary components) of the FFT with the exception of the first and last N_L where N_L = 9, 5, 3, 2, 2 for 256, 128, 67, 32, 16 bin FFTs respectively. The power output is divided by the average power of all the bins

excluding the first and last N_L, and then this value is compared to a threshold (T_D) which is determined so as to allow a certain number of crossings if the input is pure thermal noise (false alarms). The technique used is to compare each bin, scaled by the average power, with the maximum of the previous bin and a threshold T_D. The maximum bin at the end of the process which also exceeds T_D is taken as a target alarm. If no bin exceeds the threshold then no alarm is found and the detection process is applied to the next set of data. This detection method would be modified in practice to allow multiple alarms.

If a target alarm is found its bin number is output so that the doppler tracking loop and confirmation processes can act on the correct frequencies. An additional calculation is performed in the detection process. The contents of the alarm bin are reduced by the threshold. This is done because the probability distribution of the maximum bin which exceeds a given threshold is approximately a constant (T_D) plus a Rayleigh distribution (provided T_D is $> \log_e N$). By subtracting the threshold value, the initial alarm can be treated in the same way as subsequent power outputs from the bin and this simplifies the confirmation system.

The calculations performed for each bin power p_i are thus

$$r_i = p_i \Big/ \sum_{J=N_L+1}^{N-N_L} p_j \qquad (1)$$

If $r_i > T_D$ and also $> r_c^{max}$ then set $r_c^{max} = r_i$ and store i as the alarm bin number. r_c^{max} is the maximum value of r_i 'so far'. The stored value of i which remains when all bins have been considered is then the target alarm bin. This initial setting, or estimate, of the target frequency ($\hat{f}$ in Figure 2) is then employed to close the doppler tracking loop and initiate the target confirmation process.

In order to get a high probability of target acquisition with a low probability of false confirm it is necessary to incoherently sum over a large number of FFTs. To make this possible target tracking is necessary, since either the target must be kept in a fixed bin or the alarm bin must be known in some other way. For this reason a two stage acquisition process is used. The first stage which has already been described detects the whereabouts of a likely target, the second, confirmation, ensures that this detected signal is indeed a target with a high degree of certainty.

The method of operation of the confirmation process is as follows:- the 'alarm' bin is designated by the doppler tracking algorithm, except immediately after the first detect when the detection subroutine provides this information. As in the detection algorithm, the equivalent of Equation (1) above is used to provide a scaled bin output. (If the alarm bin is out of the range N_L+1 to $N-N_L$ the scaled bin is set to zero). Then this scaled 'target bin' on one FFT is added to the same quantity on the successive sample. This summing continues until a certain number of FFTs ('NFF') have been added together. At this point the sum is compared to two thresholds, an upper and lower threshold. If the sum of the bins is greater than the upper threshold then a 'confirm' flag is set, if the sum is less than the lower threshold the suspected target is rejected. If the sum is in between then the flag remains in a 'don't know' state. If the target is not rejected a further set of 'target' bins from 'NFF' FFTs are added to the first set of 'NFF' and the sum of 2'NFF' FFTs compared to two new thresholds, the upper one again denoting 'confirm' and the lower one 'reject'. After a certain number of stages ('NST') (provided an input to the program) the upper and lower thresholds are made to coincide so that

a definite decision is made. This is called the increasing sum test.

At this point a moving average of NSTxNFF FFTs begins and the criterion for confirmation is that the moving average should be above a threshold (normally taken to be the last stage threshold) and that in addition the sub-sets of 'NFF' FFTs should not reject. This latter test is put in to ensure reasonably rapid response if the target should suddenly disappear for some reason. Two tests are therefore performed. The first is to see if the moving average is above a simple threshold or not, and the second is the test on the last NTT (or 2NFF etc) FFTs compared to two thresholds. The combination of the two tests lead to one output and these are shown in the table of Figure 4.

In addition a certain amount of re-initialisation takes place. If the overall confirmation goes off 'confirm' the moving average is stopped. Also if the increasing sum test rejects or confirms the increasing sum stage is re-initialised (otherwise it continues by adding in the next 'NFF' FFTs), and each 'NFF' FFTs are tested separately.

When target confirmation is complete the 'confirm' output is used to enable the angle tracking loop and the missile guidance loop.

The Doppler Tracking system employed is to allow doppler tracking to take place both within the digital processor of Figure 2 and through an analogue VCO in Figure 1. The key function that allows tracking to take place within the data processor itself is the sliding discriminator. To form a frequency discriminator the power output of two neighbouring bins can be subtracted. If it is required to vary the position of a discriminator continuously then a technique of sliding the filters of the FFT filter will be needed to accomplish this. The following scheme is adopted. Given the complex output of two adjacent FFT bins it is possible to construct by using these two quantities alone a new FFT bin which will have as its peak any value of frequency between the mid-point of the two original bins. In order to derive a simple algorithm a rectangular window is assumed and phase factors between adjacent bins of T/N are ignored. The new FFT bin can be written approximately as

$$f(x) = \frac{\alpha \sin \pi x}{x} + \frac{\beta \sin \pi (1-x)}{(1-x)} \qquad (2)$$

where x is the fraction of a bin from the centre of the first FFT bin where the response is required.

It can be shown that if α, β take the values

$$\alpha = \frac{-\delta^2 [1 + \pi\cot\pi\delta \quad (1-\delta)]}{\pi\cot\pi\delta \quad (\delta\,(1-\delta)\,(1-2\delta)) - 1 + 2\delta - 2\delta^2} \qquad (3)$$

$$\beta = 1 - \alpha$$

then the point $f(x = \delta)$ is a maximum of the filter of Equation (2). Hence a sliding filter can be implemented by taking the frequency f evaluating the bin nearest to this and then calculating the parameters α, β needed to give two filters separated by one half a bin separation from the target frequency ($\hat{f}$). The same technique is used on the filters regardless of the type of window that is being used. The equations for the sliding filters thus become:-

$$N_{ta} = \text{Integral part of } ((f + 0.5B)\, t_s + 1.5)$$
$$x = -0.5 + N_{ta} - N_p - f\, t_s$$
$$C_1 = \alpha(x) \text{ (where } \alpha \text{ is given by a pre calculated set of values)} \qquad (4)$$
$$C_a = C_1\, b(N_{ta} - 1) - (1 - C_1)\, b(N_{ta})$$
$$C_b = (1 - C_1)\, b(N_{ta} + 1) - C_1\, b(N_{ta})$$

where $\hat{f}$ is the doppler frequency according to the digital tracking loop, B is the FFT bandwidth, t_s is the update time, N_p is half the number of bins in the FFT and b(N) is the N^{th} FFT bin (complex). Thus C_a and C_b are the two sliding filter outputs, and are again complex.

It is then necessary to construct the discriminator, and this can be done by taking $d = |C_a|^2 - |C_b|^2$. However the sliding filter technique results in a scaling at the origin of this quantity which depends on filter position and hence a correction for this has to be applied. A quadratic correction term is used of the form

$$S_d = a_1 + a_2 \bar{x} + a_e \bar{x}^2 \qquad (5)$$

where $\bar{x}$ = min (x, 1-x) and a_1, a_2, a_3 take various values for the different window functions being used. This also allows the discriminator to be automatically scaled for the appropriate window function.

The discriminator 'd' must also be automatically gain controlled and this is accomplished by a simple first order feedback system operating off a square law detector. The detector operates off a new bin of the form

$$C_{agc} = C_a + C_b \qquad (6)$$

which gives a filter centred on the target frequency. In conjunction with the discriminator this is believed to give optimum performance. The agc is thus

$$Agc_n = Agc_{n-1}k + (1-k) \; |c_{agc}|^2 \; S_c \qquad (7)$$

where S_c is another scale correcting factor for the different gains found at different positions of the sliding filter and different windows. This is given by

$$S_c = 1 + \bar{x}\, b_1 + \bar{x}^2 b_2 \qquad (8)$$

where b_1 and b_2 are constants depending on the type of window. k equals exp $(-t_s/t_{agc})$ where t_{agc} is the agc time constant. The resultant discriminator output ε_d is

$$\varepsilon_d = d\, S_c\, S_d/(Agc_n\, t_s)\ \text{Hz} \qquad (9)$$

The digital tracking loop is closed entirely within the data processor (see Figure 2) and provides the estimate of target frequency $\tilde{f}$ that is needed for the confirmation process. The particular implementation used is a type two loop. A block diagram of the system is shown in Figure 2.

It can be seen that there are two outputs of the loop, one for the confirmation process ($\tilde{f}$) and one feedback ($\hat{f}$) to the sliding discriminator. The transfer functions of these two are different and are given by

$$\frac{\hat{f}}{f} = \frac{z^2 g\,(1 + G) - gz}{z^2 + z\,(g\,(1 + G) - 2) + (1 - g)}$$

$$\frac{\tilde{f}}{f} = \frac{z^2 g + g\,(G - 1)z}{z^2 + z\,(g\,(1 + G) - 2) + (1 - g)} \qquad (10)$$

Where f is the target frequency relative to the centre of the IF sum channel. These transfer functions are implemented by taking the output of the discriminator ε_d and then multiplying by the gain g_1(G1).

The algorithms for the implementation of these two closed loop transfer functions are as follows. If the agc'd discriminator output is ε_d then

$$f_1(n) = f_1(n-1) + g_1 d$$

$$f_2(n) = f_2(n-1) + g_2 f_1(n)$$

to sliding discriminator $$\hat{f}(n) = f_1(n) + f_2(n) \qquad (11)$$

to confirmation $$\tilde{f}(n) = f_1(n) + f_2(n-1)$$

The doppler loop described so far thus gives a signal $\hat{f}$ indicative of the target frequency f relative to the centre frequency of the speed gate (see Fig. 1). The frequency error ε_d is added to f and multiplied by a variable gain G3 which feeds into the digital/analogue converter (DAC) of Figure 1. This signal labelled 'DTL O/P' is fed to an integrator to control a voltage controlled oscillator. Added in to the integrator input is a further input from an accelerometer to give a rate assistance component to the doppler tracking loop. The VCO signal is mixed with the LO signal and the difference frequency is extracted in the single sideband mixer, amplified and transmitted from the aerial via the circulator. The loop settles when 'DTL O/P' is zero, i.e. when the transmitter frequency is such that the target return frequency is centred in the first speedgate(24).

The parameters in the doppler loop are made adaptive to allow for changing target conditions so that optimum performance is maintained at all times. Referring to Figure 2:

(i) Immediately after target detection,gains G1, G2 and G3 are set to high values so that the loop settles quickly. The gains are then reduced until, after a pre-determined length of time, the gains take constant lower values to reduce the noise in the loop. The gains are increased as the missile flight progresses according to the signal strength measured in the agc amplifiers (connection from agc not shown), or by other signal to noise assessment methods (see later), and according to the FFT bin width selected (see below).

(ii) During the missile boost phase, the doppler tracking loop experiences substantial transients and the FFT bin width is selected to be a large value (note the bin width equals the total FFT bandwidth divided by the number of FFT bins.) Gains G1, G2 and G3 are set to high values to give a rapid response.

(iii) If a target at long range is to be acquired, the FFT bin width is set to be very narrow, and G1 G2 and G3 are set to low values after loop pull in. This optimises the acquisition threshold.

(iv) If the target is at short range the FFT binwidth is set to be wide and G1 G2 and G3 are set to high values. This optimises acquisition speed and minimises tracking errors. A wide FFT binwidth gives a faster update rate and hence gives the optimum performance very close to impact when rapid response is important. Target (2) range is determined from the range tracking loop (Figure 1).

(v) Once the loop has pulled-in, the signal $\hat{f}$ is proportional to the target frequency rate, i.e. the target acceleration. If $\hat{f}$ is large the FFT binwidth is set to a high value to allow a rapid tracking ability. The loss in doppler discrimination against other targets at similar speeds is not important since a manoeuvring target is not able to keep in close proximity to other targets. When $\hat{f}$ is small, a small

FFT binwidth is used to give maximum doppler discrimination against targets flying in formation.

(vi) When multiple targets in close proximity are detected (see later) or the target acceleration is small the FFT binwidth is set to a low value to give maximum doppler discrimination.

The design of the overall angle tracking system can be conveniently divided into three parts. Firstly the EAT receiver, secondly the angle tracking filter and thirdly the servo control and stabilisation system.

A block diagram of the complete angle tracking and servo control system is shown in Figure 5. The angle tracking filter estimate of angle in the two channels (see below) is used to add a controlled portion of the sum channel which corresponds to these angles according to the stored D/S slope at the origin, into the difference channels as in Figure 1. These difference channels then pass through the same IF chain as the sum channel, are sampled and analogue-to-digital converted. They are then Fourier Transformed to give the spectrum of signals on the azimuth and elevation channels. The sum and difference channels are agc'd digitally and elevation and azimuth phase-sensitive-detector outputs

are formed by taking the real part of DXS; these outputs are proportional to the angular error between the true target position and the best estimate of the target position. These calculations are all performed at the same update rate as the doppler and range tracking loops.

After the PSD's it is necessary to perform an axis transformation in order to transform from receiver axes to line of sight axes. This is implemented digitally. These signals are then passed through an angle tracking (Kalman) filter which produces best estimates of sight line rate using a variable gain algorithm. The sight line rate signals are used in various ways; firstly they provide an output to the autopilot as the guidance command for which purpose they are transformed into missile axes; they are also used as the input to the EAT integrator which feeds estimate of angle back to the EAT element and finally it is used as input to the line of sight observer to drive the antenna mechanism. This latter is added to an inertial reference unit (IRU) gyro output in order to provide the total movement of the target as measured in line of sight axes.

These angular rates are still calculated at the (low) update rate of the loop. These rates are then integrated using a high update digital integrator and

and the output is transformed from line of sight axes into motor shaft angles using digital axes transformations. The angle demands are then used to control a position control loop for the antenna. The angle demand is subtracted from the potentiometer pick-offs and the error is fed into a controller which feeds demands to the antenna mechanism, servo and motors. The antenna/ reflector plate is thus position slaved to the integrated IRU gyro and the target sight line error. A high update rate controller is used. The effect of this is to remove body motions on the receiver output. An additional line of sight feed back is used to the EAT element. This is added to the other feedback path and ensures that the best estimate of sight line error can be used to subtract from the actual sight line error for EAT. The combined EAT feedback path has to be angle transformed back into receiver axes and a radome aberration correction is added in, as a function of the gimbal angles, as indicated in Figure 3.

The angle tracking loop of Figure 3 will now be described in some detail. The sum and difference FFT outputs in Figure 1 are used to derive the target boresight error signal (i.e. the target angle off aerial boresight) in a manner illustrated in Figure 3. The sliding filters are similar to those described for

Figure 2 and are controlled to be centred at frequency f. The circuit forms the product of sum and complex conjugate of difference and takes the real part. This function is equivalent to that of a phase sensitive detector (also called a coherent detector). This signal is divided by the agc detector output to give the amplitude ratio for each of the two channels i.e. $\frac{(D_e - k_e S)S}{\overline{S^2}}$ and

$\frac{(D_a - k_a S)S}{\overline{S^2}}$ where $\overline{S^2}$, the mean square of the sum signal, is the output of the agc detector. Only the elevation difference channel is shown but the azimuth difference channel is treated similarly. This is fed through a filter (e.g. a Kalman filter) to give an output $\hat{\varepsilon}$. $\hat{\varepsilon}$ is added to an aberration correction factor and fed to the EAT gain element to close the loop. The servo control output from the filter is a separately filtered version of $\hat{\varepsilon}$ and drives the servo motors of the antenna mechanism.

The aberration corrector gives outputs equal to the azimuth and elevation aberration levels of the radome as a function of the inputs. A function is stored in the memory of the corrector which takes account of the transmitter frequency selected, the measured temperature of the radome and the two gimbal angles.

When the EAT loop is in equilibrium $\hat{\varepsilon}$ gives the true measure of the boresight error, with the aberration error subtracted.

The Kalman filter parameters are varied as a function of conditions during missile flight and in general are arranged to give high bandwidth when the estimated time to impact is small. Time to impact is estimated by dividing the missile-target range (from the range tracking loop) by the closing velocity (from the doppler tracking loop). The filter bandwidth is also made a function of signal to noise ratio, the bandwidth being low when the signal to noise ratio is low.

Signal to noise ratio can be derived in two ways. Firstly, the confirmation circuit of Figure 1 can be adapted to measure the S/N by forming the ratio of the power in the target FFT bin to the average power in the adjacent bins. Secondly, as shown in Figure 3, a signal to noise indicator can be derived by taking the imaginary part of the product of the sum and difference channels and dividing by the agc detector output. This gives an indication of the power of the signal components that are either incoherent between the sum and difference channels or in phase quadrature. The 'incoherent' power component is large when thermal noise or jamming in either the sum or the difference channels is large, and

tends to zero at high signal to noise ratio. The output is also large on extended targets or on targets flying in formation that are unresolved by the seeker. The ratio of the 'incoherent' power component to the signal to noise ratio indicated by confirmation-circuit is therefore an indicator of targets in close proximity, a large output indicating the presence of multiple targets.

UK SECRET

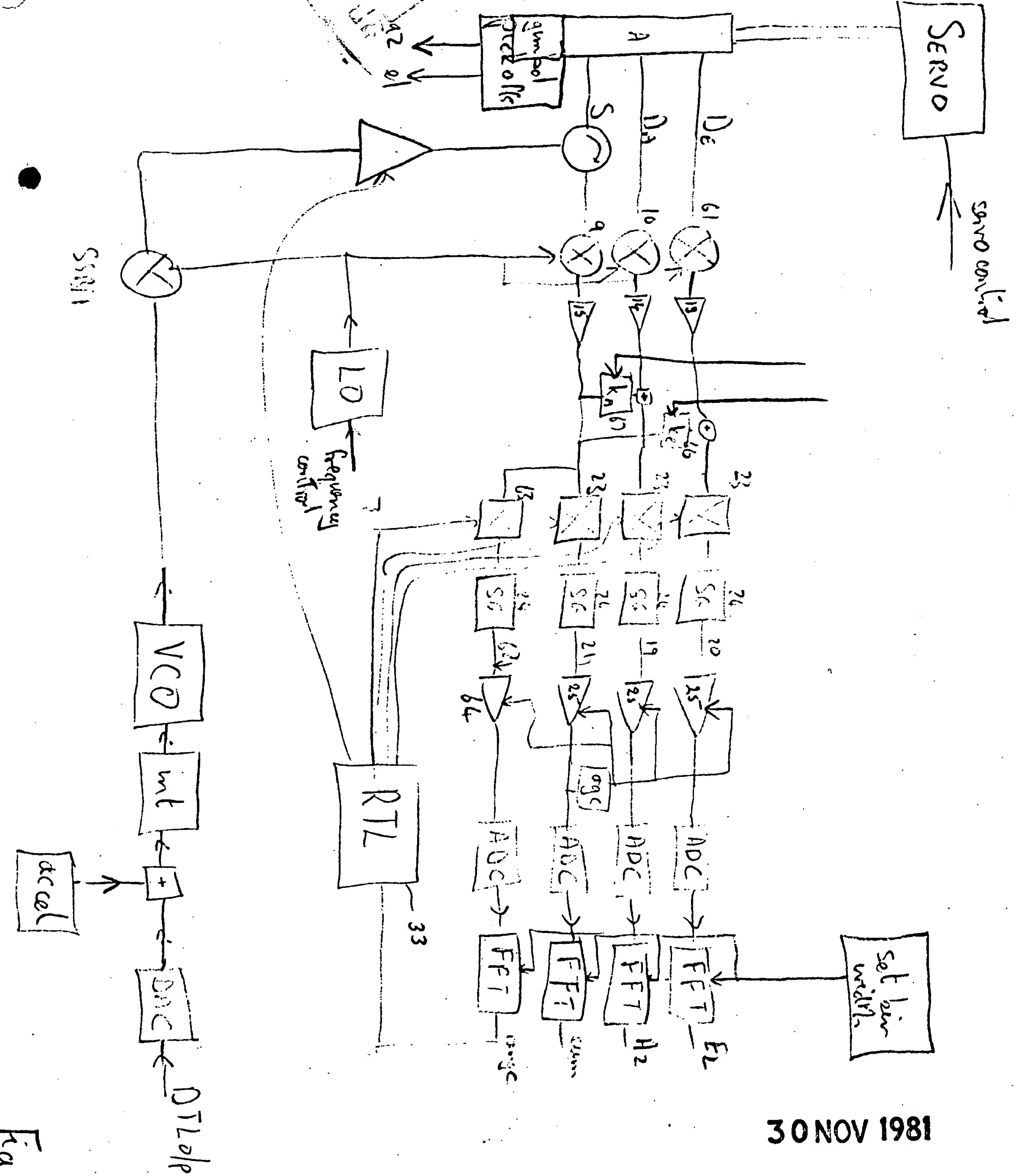

Fig 1

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30 NOV 1981

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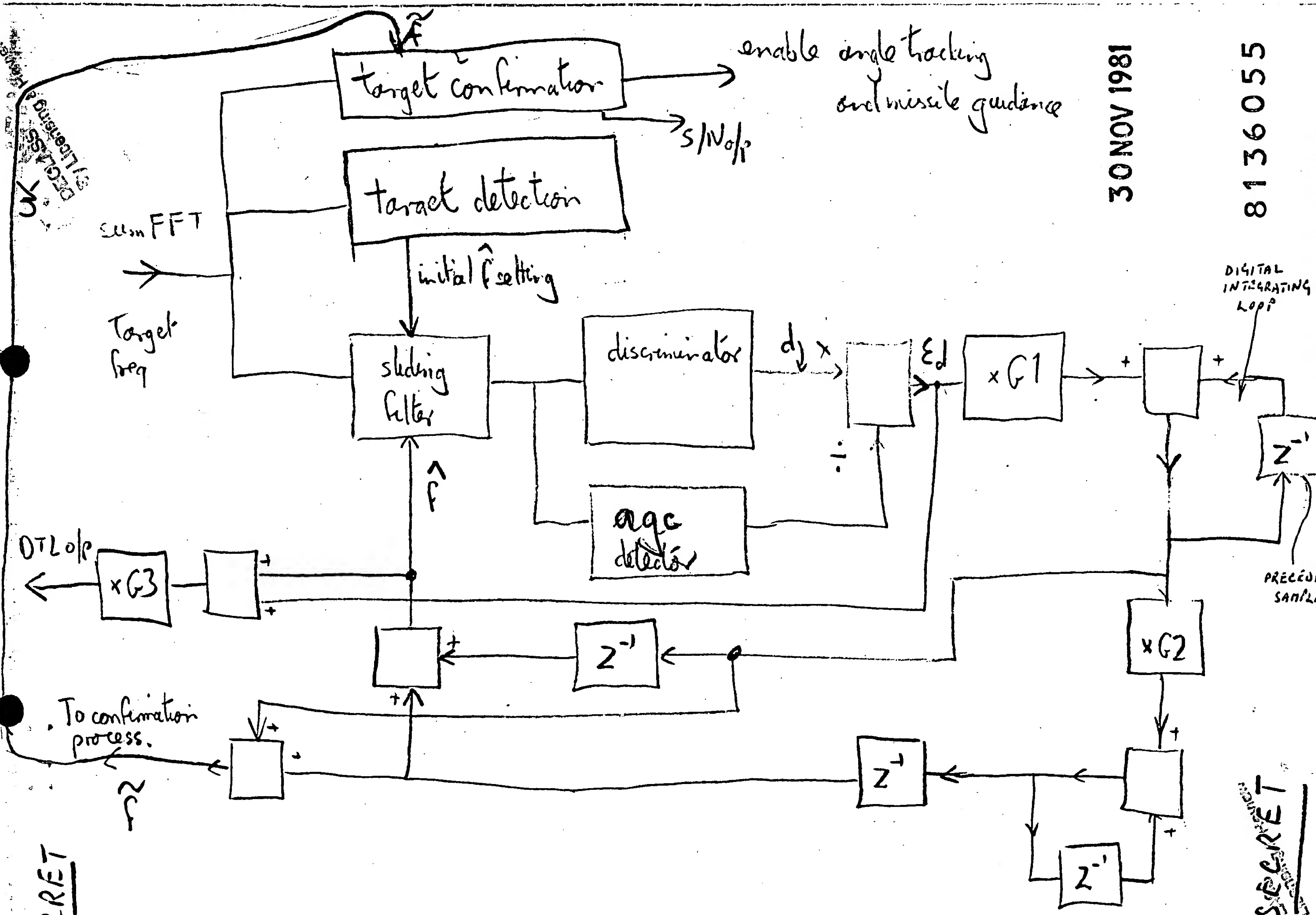

Doppler Tracking Loop – Digital data processor section Fig 2

UK SECRET

NOT TO BE AMENDED

SECRET

FIG 3

30 NOV 1981

8136055

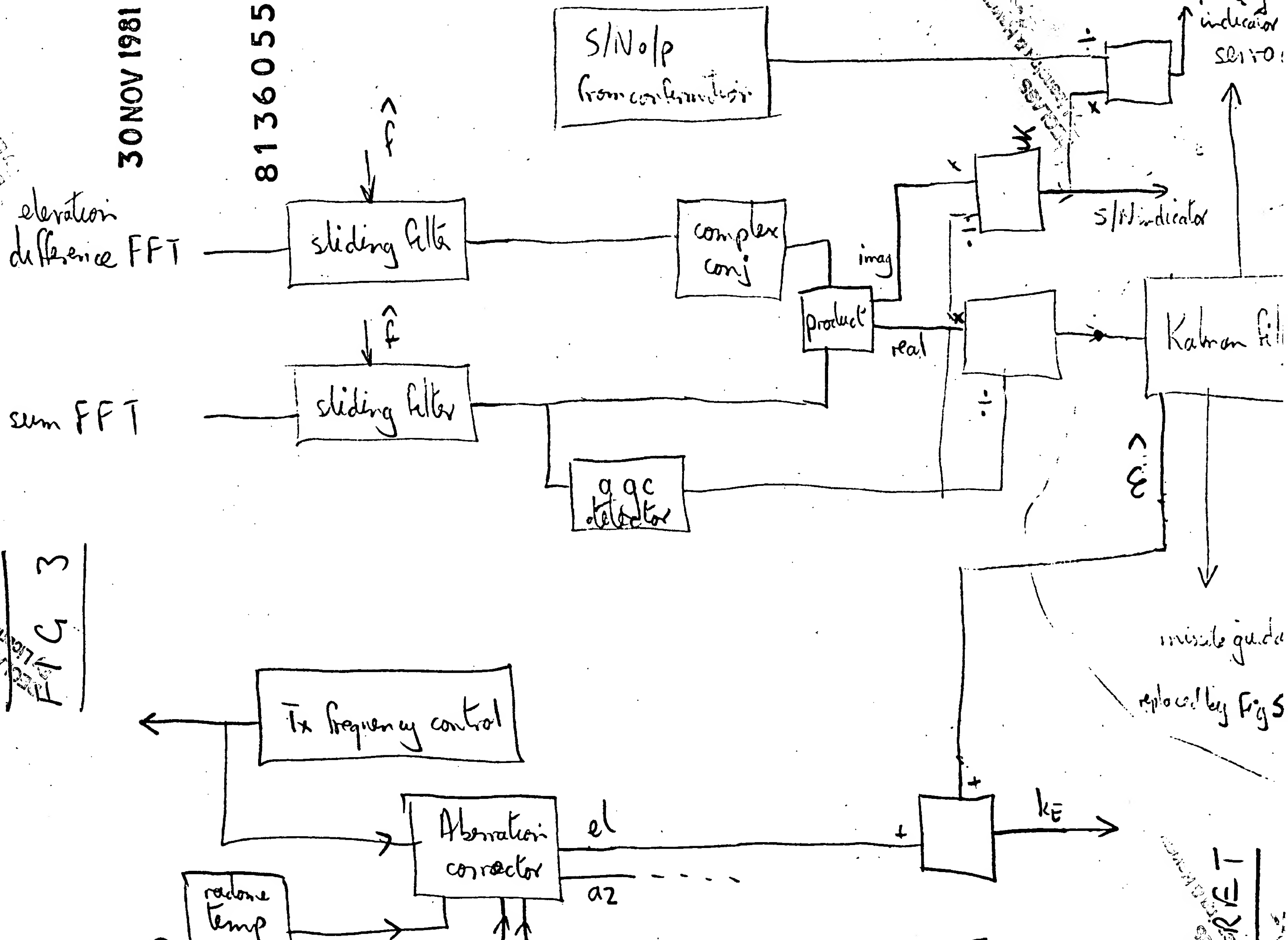

Figure 3
Angle Tracking loop.

SECRET

UK SECRET

SECRET

Moving Average \ Increasing Sum Test	Reject	Don't Know	Confirm
Confirm	Don't Know	Confirm	Confirm
Reject	Reject	Don't Know	Confirm

FIG 4

30 NOV 1981

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NOT TO BE AMENDED

UK SECRET

SECRET

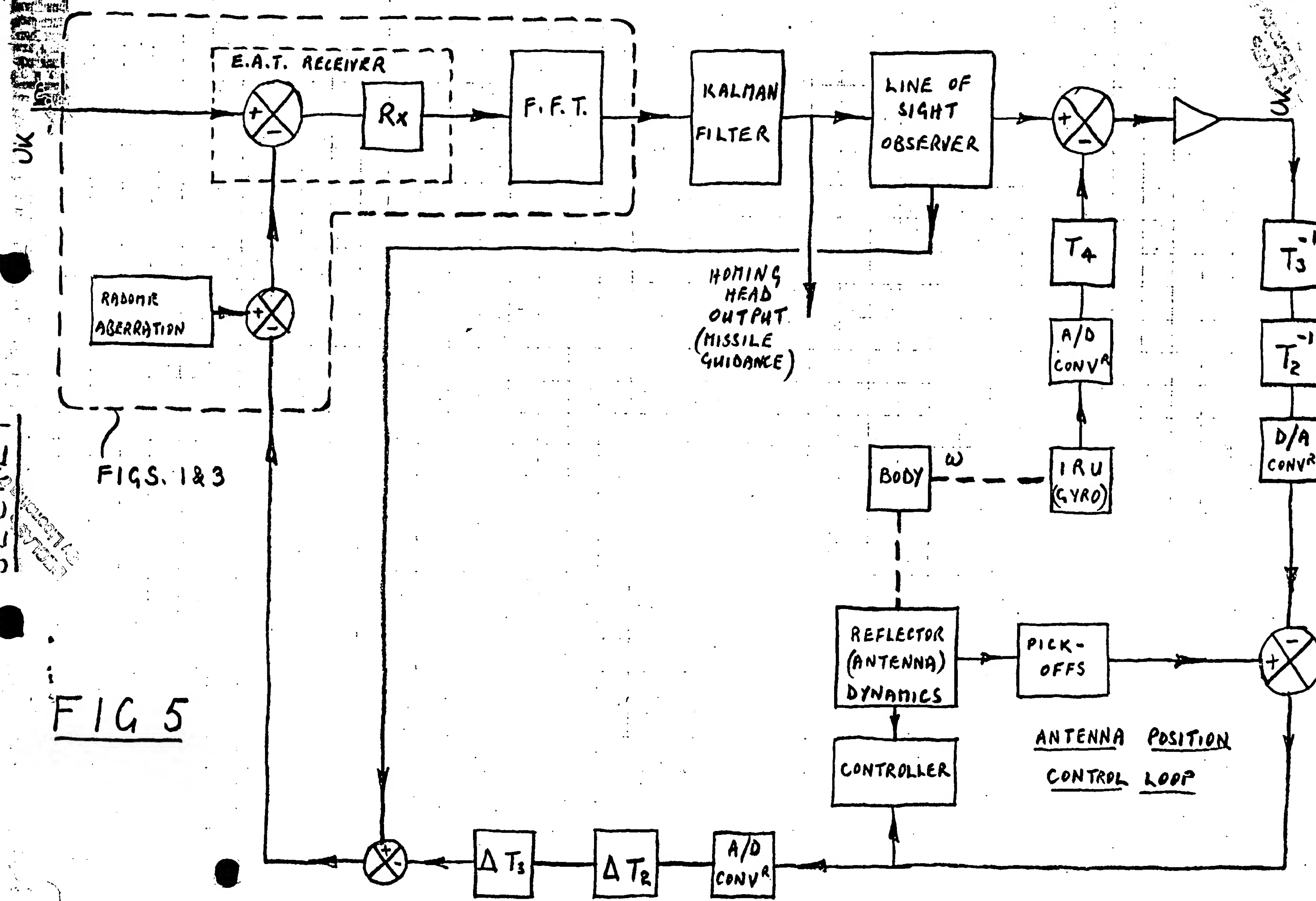
UK
E.A.T. RECEIVER
Rx
F.F.T.
KALMAN FILTER
LINE OF SIGHT OBSERVER
UK
T_4
T_3^{-1}
T_2^{-1}
RADOME ABERRATION
HOMING HEAD OUTPUT (MISSILE GUIDANCE)
A/D CONV^R
D/A CONV^R
BODY
ω
IRU (GYRO)
FIGS. 1&3
REFLECTOR (ANTENNA) DYNAMICS
PICK-OFFS
ANTENNA POSITION CONTROL LOOP
CONTROLLER
ΔT_3
ΔT_2
A/D CONV^R

FIG 5